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LARVAL DEVELOPMENT OF *DIOGENES BICRISTIMANUS* IN THE LABORATORY

By R. Sarojini and R. Nagabushanam

Zoological Department, Marathwada University, Aurangabad

Earlier studies on the hermit crab development were based on the planktonic material. Thompson (1904) described the development of *Pagurus longicarpus* and *P. annulipes* by studying the larvae taken from the plankton and rearing them in the laboratory. The method used by Thompson (1904) was later followed by MacDonald, Pike and Williamson (1957) and Dechance (1961) to study the larval development of various hermit crabs. The larval and adult stages of anomurans near British Columbia, Canada, were studied by Hart (1937), while Dechance and Forest (1958) described the Glaucothoe stage of *Catapaguroides timidus* and *Clibanarius erythropus*. Coffin (1958) studied the complete development of *Pagurus samuelis* using the recent development techniques for rearing decapod larvae in the laboratory.

In tropical waters the larval development of hermit crabs was less studied. Menon (1937) described the development of *Spiropagurus spiriger* and *Diogenes pugilator* from Madras. But his studies were based on the material collected from plankton. The most important contribution in the larval development of tropical hermit crabs was made by Provenzano (1962 a and b, 1963 a and b), Provenzano and Rice (1964) and Rice and Provenzano (1965).

In the present chapter the complete larval development of *Diogenes bicristimanus* is described.

Material and Methods

Ovigerous females of *Diogenes bicristimanus* were collected on 20th January, 1964, from Lawson's Bay, Waltair. The animals were kept individually in glass bowls containing sea water. Twenty liberated larvae were placed individually in syracause watch glasses containing filtered sea water. Freshly hatched *Artemia nauplii* were added to the watch glasses as food. The larvae were kept at a temperature ranging from 24° to 28°C. and the salinity for all the larvae varied from 32 to 33‰. The watch glasses were examined daily for exuviae and dead specimens. Larvae were transferred every day to fresh containers. Larvae and exuviae of known history were preserved in 5-7% sea water formalin.

Fresh plankton was also observed in the laboratory. Known larval stages were picked up from the plankton and also reared in the laboratory.

Drawings were made with the aid of a camera lucida and measurements were made with the ocular micrometer. Total length was measured from the tip of the rostrum to the posterior border of the telson exclusive of the telson processes. Length

of carapace was measured from the tip of the rostrum to the postero-lateral margin of the carapace. The system followed by Pike and Williamson (1960) and Provenzano (1962 a and b) was used in the numbering of the telson processes.

Duration refers to time spent in a given stage by larvae which survived to moult to the succeeding stage. The term stage as used herein refers to an intermoult phase of larval development.

RESULTS

Diogenes bicristimanus reared in the Laboratory attained glaucothoe stage after five zoaea intermoults.

First zoaea (Pl. 1, Fig. 1, I)

Size : Total length—1.2 mm., carapace length—0.5 mm. Duration : 2-4 days.

The larvae are fairly stoutly built. The carapace is more or less oval in shape. Anteriorly it is produced into a long rostrum which extends well beyond the antennule and antennal scale. The posterolateral margins of the carapace are smoothly rounded. The eyes are sessile and large. Their length is equal to about 1/4 of that of the carapace. Small mid-dorsal spines are present on the 3rd and 4th abdominal segments. The 5th abdominal somite has a stout mid-dorsal spine and on each side is a large lateral spine. The 6th somite is fused with the telson. The telson is broader than long and the posterior margin is straight except for a prominent median notch. There are 6 spines and a hair on each side of the posterior margin. Except for the outermost, the telson spines are long and slender and joined to the telson. The 4th telson spine is longest. Red chromatophores are present on the cephalothorax and abdomen (Pl. 1, Fig. 2, I).

Antennule (Pl. 2, Fig. 1, I). This is an unjointed process. The inner ramus is minute and bears a single long seta. The outer ramus bears three aesthetes and a couple of setae terminally.

Antenna (Pl. 2, Fig. 2, I). A peduncle, scale and flagellum are present. The peduncle bears a large spine at the base of the flagellum. The scale is broad and curved with the length about three times the width. It has a terminal spine and 9 plumose setae on the inner margin.

Mandible. It has no palp.

First maxilla (Pl. 2, Fig. 3, I). This bears a proximal endite with setae, a distal endite with two serrated spines and a small two-segmented palp with two spines.

Second maxilla (Pl. 3, Fig. 1, I). This has two bilobed setose endites and unsegmented palp with two terminal setae. The scaphognathite bears 6 setae and no proximal process is present.

First maxilliped (Pl. 3, Fig. 2, I). The coxa is unarmed and the basis has five setae on the inner margin. The endopod is 5 jointed. The segments 1, 2 and 4 have each 2 setae while the 3rd segment has only 1 seta. The 5th segment has 4 terminal setae and 1 on the outer margin. Exopod is 2 jointed bearing 4 plumose setae.

Second maxilliped (Pl. 4, Fig. 1, I). The basis has only 2 setae. The coxa is unarmed. Endopod is only 4 jointed. Segments 1, 2 and 3 have 2 setae. The 4th segment has 4 setae. The exopod is similar to that of the 1st maxilliped.

Third maxilliped (Pl. 4, Fig. 2, I). This appendage is only an elongated rudiment without any setae.

Behind the 3rd maxilliped there are rudiments of 3 pairs of pereiopods.

Second zoaea (Pl. 1, Fig. 1, II)

Size: Total length—1.5 mm., carapace length—0.8 mm. Duration: 2-4 days.

In general appearance the larva has not changed much except it has grown a little bit bigger in size. The telson is still fused with the 6th abdominal segment. An additional pair of telson spines are present and these are about half the length of the 6th pair (Pl. 1, Fig. 2, II). The eyes are movable.

Antennule (Pl. 2, Fig. 1, II). This is still an unjointed appendage and the plumose setae now spring from a small papilla which would eventually become the inner flagellum and opposite to it there is a couple of setae.

Antenna (Pl. 2, Fig. 2, II). The endopod has two prominent setae at the end. The scale is just like in the previous stage except that the number of setae has increased to eleven. It is still an unsegmented appendage.

Mandible. Few more additional teeth have appeared on the cutting edges.

First maxilla (Pl. 2, Fig. 3, II). The distal endite has 4 setae. The palp has 2 setae, one terminal and the other some distance behind.

Second maxilla (Pl. 3, Fig. 1, II). This remains unaltered from the first zoaeal stage.

First maxilliped (Pl. 3, Fig. 2, II). Segments 1 to 3 of the endopod have outer setae also. Exopod has 6 setae.

Second maxilliped (Pl. 4, Fig. 1, II). Only the 3rd segment of the endopod has developed an outer seta. The exopod is similar to that of the first maxilliped.

Third maxilliped (Pl. 4, Fig. 2, II). The exopod is well developed and functional, having 6 plumose setae. The endopod is a knob springing from the base of the basis.

Pereiopods. Rudiments of all the pereiopods are present.

Third zoaea (Pl. 1, Fig. 1, III)

Size: total length—1.9 mm., carapace length—1.1 mm. Duration: 2-3 days.

One specimen was obtained from the plankton. This one moulted to fourth zoaea in the laboratory. Five more specimens were obtained by rearing the second zoaea in the laboratory.

The most important development in this stage is the differentiation of the 6th abdominal segment from the telson. The uropods made their appearance. The

median notch in the telson has disappeared. The 3rd telson spine is very slender and reduced to less than half its length of the previous stage (Pl. 1, Fig. 2, III).

Antennule (Pl. 2, Fig. 1, III). The flagella and the peduncle are now clearly marked out. The peduncle bears a few setae at its distal end. The outer flagellum has 4 aesthetes and 3 or 4 setae whereas the inner flagellum is just a knob tipped with a single seta.

Antenna (Pl. 2, Fig. 2, III). The antennal endopod is about 2/3 the length of the scale and carries only one small sub-terminal seta. The scale has 12 plumose setae on its inner edge.

The mandibles and first maxillae show little changes from the previous stage.

Second maxilla (Pl. 3, Fig. 1, III). The scaphognathite has a small proximal process without setae.

The first and second maxillipeds do not show any change from the previous stage (Pl. 3, Fig. 2, III and Pl. 4, Fig. 1, III).

Third maxilliped (Pl. 4, Fig. 2, III). The exopod is unchanged but the endopod has grown to some extent.

Pereiopods. The rudiments of the thoracic appendages are slightly more developed; gills not yet developed.

Uropods. These are unsegmented. The endopod is without setae and is about 1/3 the length of the exopod. The exopod bears 7 setae on the inner margin and a terminal spine. This spine reaches as far as the outermost telson spine.

Fourth zoaea (Pl. 1, Fig. 1, IV)

Size: total length—2.3 mm., carapace length—1.4 mm. Duration: 2 days.

Two specimens were obtained from third zoaea reared in the laboratory. No trace of 3rd telson spine can be seen but the space between the 2nd and 4th is slightly greater than between other adjacent spines (Pl. 1, Fig. 2, IV).

Antennule (Pl. 2, Fig. 1, IV). The inner flagellum has elongated a little.

Antenna (Pl. 2, Fig. 2, IV). The endopod is longer than the scale and show traces of segmentation.

Mandible. It is still without palp.

First maxilla (Pl. 2, Fig. 3, IV). This remains two-jointed.

Second maxilla (Pl. 3, Fig. 1, IV). The proximal extensions of the scaphognathite is larger than in stage III and is still without setae.

First, second and third maxillipeds. The exopod of each maxilliped bears 6 setae (Pl. 3, Fig. 2, IV and Pl. 4, Figs. 1 and 2, IV).

Pereiopods. They are unsegmented but rudimentary chelae are present on the first pair.

No pleopods are present but the 2nd and 3rd abdominal segments are rather swollen ventrally.

Uropods. Both the exopod and endopod articulate with the base. The endopod bears a single terminal seta while the exopod bears 7 setae as in the preceding stage. The terminal spine is about twice as long as in stage III and reaches beyond the outer telson spine.

Fifth zoaea (Pl. 1, Fig. 1, V)

Size : total length—2.4 mm., carapace length—1.4 mm. Duration : 2 days.

The larvae have not grown in size. The appearance of pleopod in the 2nd and 3rd abdominal somites is the distinguishing character of this stage.

Antennule (Pl. 2, Fig. 1, V). It is like in the previous stage.

Antenna (Pl. 2, Fig. 2, V). The endopod is divided into two segments.

Mandible. Rudimental palp has developed.

First maxilla (Pl. 2, Fig. 3, V). It is unaltered.

Second maxilla (Pl. 3, Fig. 1, V). The scale has now the characteristic posterior lobe devoid of setae.

First and second maxillipeds (Pl. 3, Fig. 2, V and Pl. 4, Fig. 1, V). They are unaltered.

Third maxilliped (Pl. 4, Fig. 2, V). The endopod has grown still further and is jointed though not distinctly.

Pereiopods. All the pereipod rudiments have also grown considerably and show all the segments of the adult limb.

Rudiments of gills are present. The 2nd and 3rd abdominal segments have got uniramous, unjointed pleopod rudiments.

Uropods. Only the endopod shows growth but no setae on it.

Telson (Pl. 1, Fig. 2, V). This is similar to that of the previous stage.

Glaucothoe stage (Pls. 1-5, Figs. 1-3 G)

Size : total length—1.6 mm., carapace length—0.9 mm.

One specimen was obtained in the laboratory from that of last zoaeal stage. Two more were obtained from the plankton.

The glaucothoe is stockily built with the abdomen stouter than the carapace. There is a small, blunt rostrum. The posterior margin of the telson is distinctly concave. The eyestalks are convex on the outside. The ocular scales are well developed. The peduncle of the antennules reach about as far as the joints of the eyes. The inner ramus is two-jointed, the outer four-jointed and bears 5 aesthetes. The antenna is short and stout. Four joints are distinguishable in the peduncle and 6 or 7 in the flagellum.

The left cheliped is much larger than the right. They bear a few setae and no spines. All the other pereiopods are longer in relation to body size ; the 2nd and

3rd bear setae but no spines, the 4th and 5th bear short terminal spines. The 4th subchelate and the 5th chelate.

Symmetrical, uniramous, two-jointed pleopods, each with 6 long terminal setae on the 2nd and 3rd abdominal segments. The uropods are biramous with short terminal spines on each ramus. The left uropod is considerably the larger.

Discussion

Menon (1937) studied the development of *Diogenes pugilator* from Madras coast. In his study he found that *D. pugilator* passes through only four zoaeal stages before attaining the glaucothoe stage. MacDonald, Pike and Williamson (1957) also studied the larval development of *D. pugilator* from British seas. During their work they also came across four zoaeal stages but suggested that there might be a fifth zoaeal stage which they could not get. The fourth zoaea which they got lacked the mandibular palp and pleopods.

In the present study on the larval development of *Diogenes bicristimanus* there are five zoaeal stages before it reaches the glaucothoe stage. The larval development in the beginning was a little bit slow but as the larva advanced in age the development was quicker. The ocular scales are well developed; no spines on the merus of the left cheliped in the glaucothoe stage. In *D. pugilator* the ocular scales are very small and no spines are present on the merus of the left cheliped in the glaucothoe stage (Menon, 1937). However, MacDonald *et al.* (1957) found one or two blunt spines on the merus. They also described yellow, white and red chromatophores in the zoaeal stages but in the present study only red chromatophores are found.

Summary

1. The larval development of *Diogenes bicristimanus* was studied in the laboratory by rearing the larvae liberated by ovigerous females and also from the larvae obtained in the plankton. The larvae were kept at temperature ranging from 24° to 28°C. and the salinity varied from 32 to 33‰.

2. Five zoaeal stages and the glaucothoe were described and illustrated.

3. The zoaeal stages and the glaucothoe were compared with other species of the genus and there was close similarity of larval characters of species within a genus.

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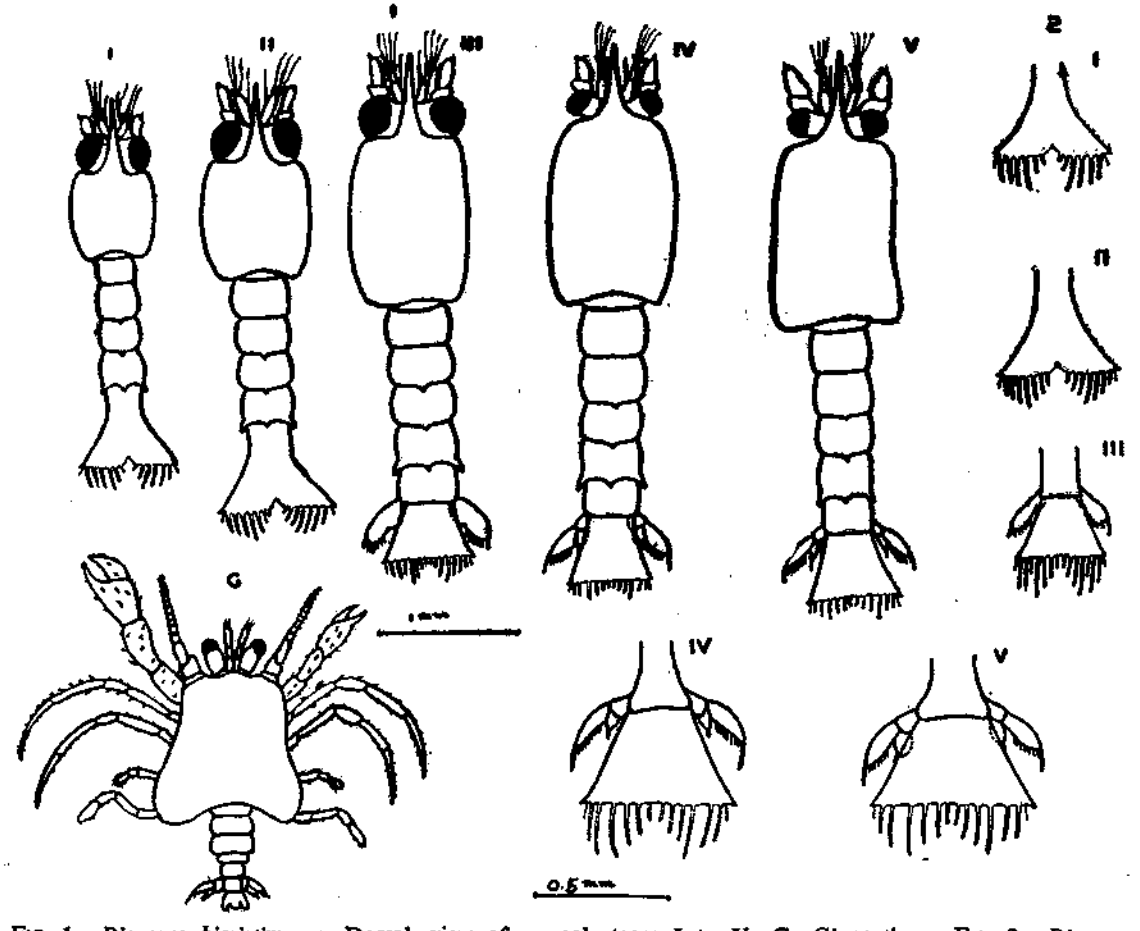


FIG. 1. *Diogenes bicristimanus*, Dorsal view of zoaeal stages I to V, G=Glaucothoe. FIG. 2. *Diogenes bicristimanus*, Telson of zoaeal stages I to V.

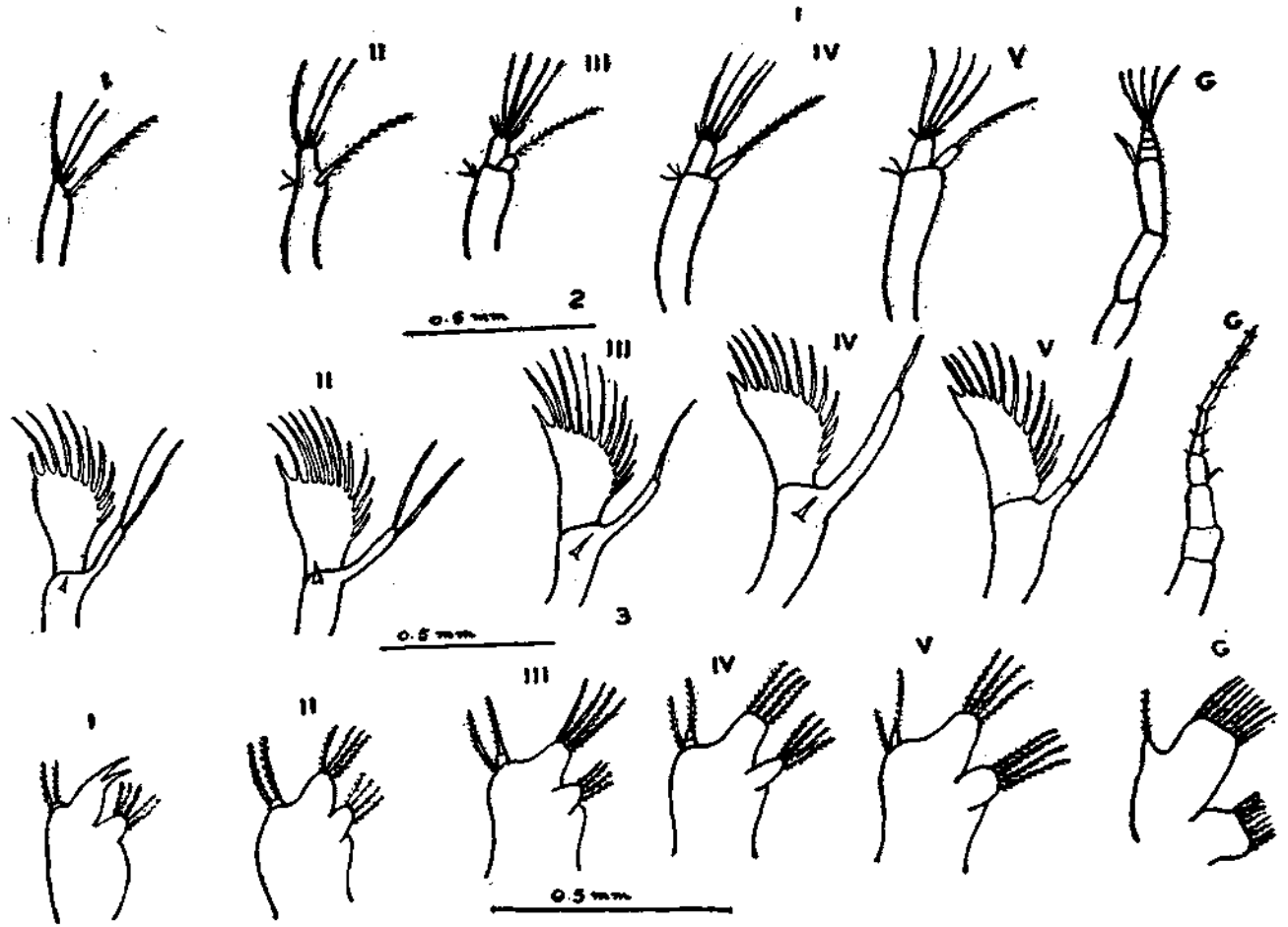


FIG. 1. *Diogenes*, antennules of zoaeal stages I to V and glaucothoe (G). FIG. 2. *Diogenes*, antenna of zoaeal stages I to V and glaucothoe (G). FIG. 3. *Diogenes*, 1st maxilla of zoaeal stages I to V and glaucothoe (G).

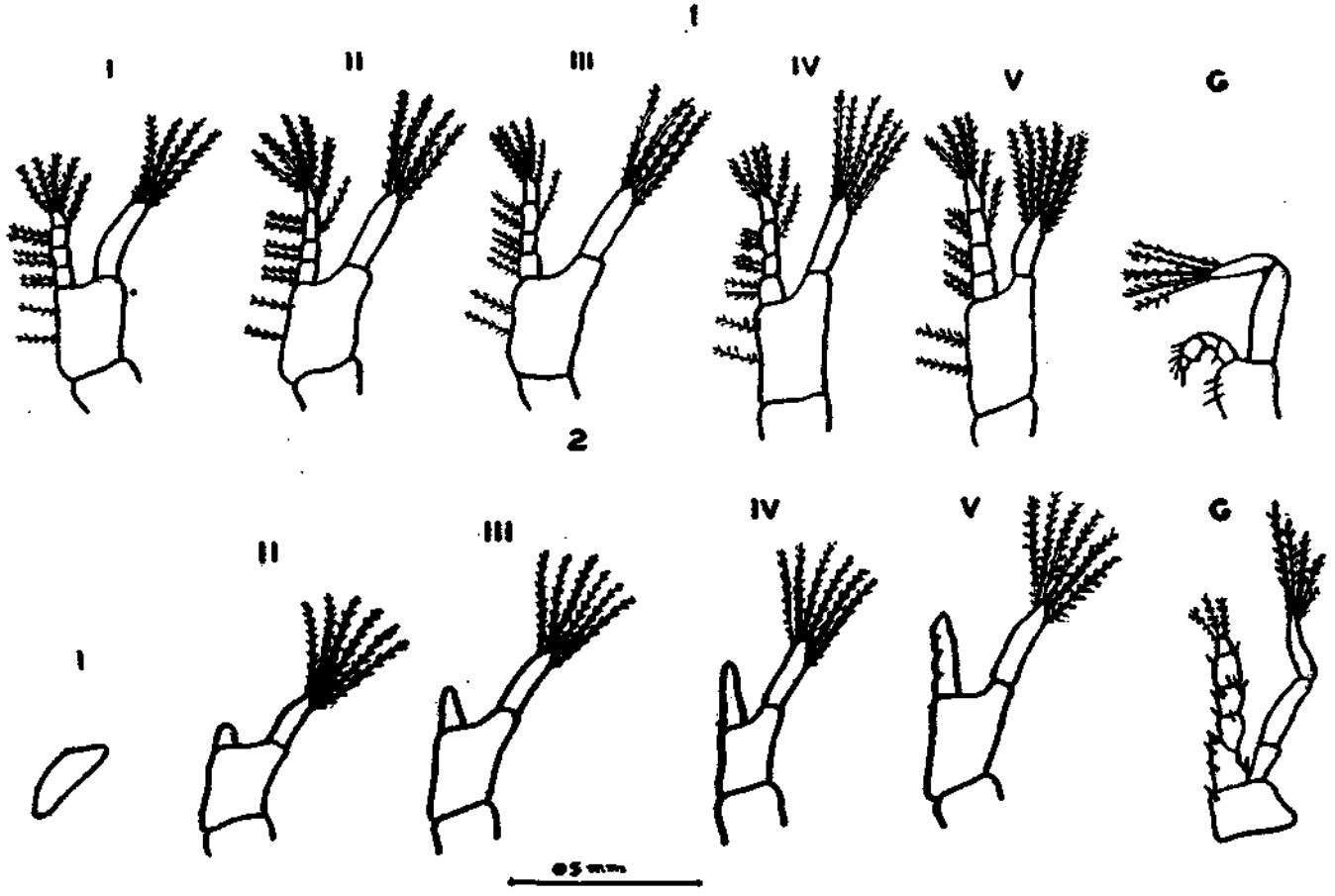
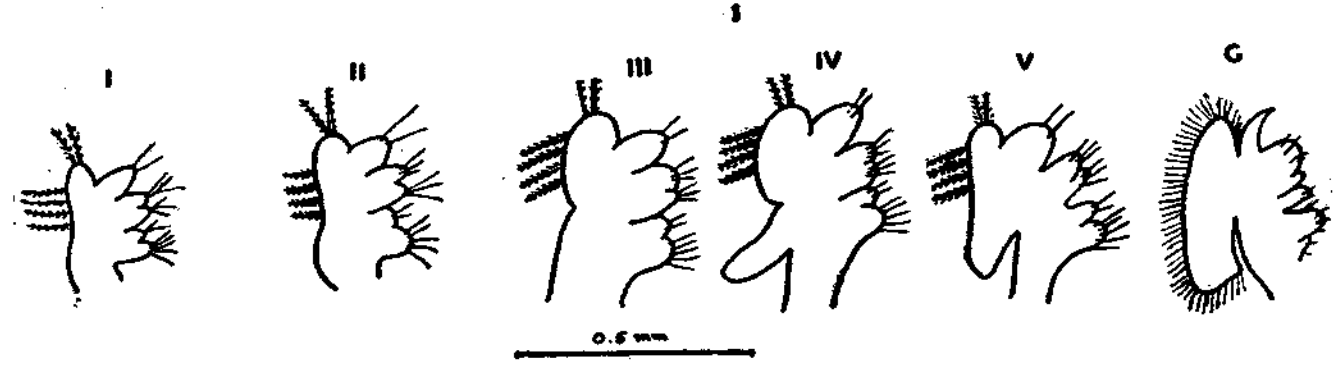


FIG. 1. *Diogenes*, 2nd maxilliped of zoaeal stages I to V and glaucothoe (G). FIG. 2. *Diogenes*, 3rd maxilliped of zoaeal stages I to V and glaucothoe (G).



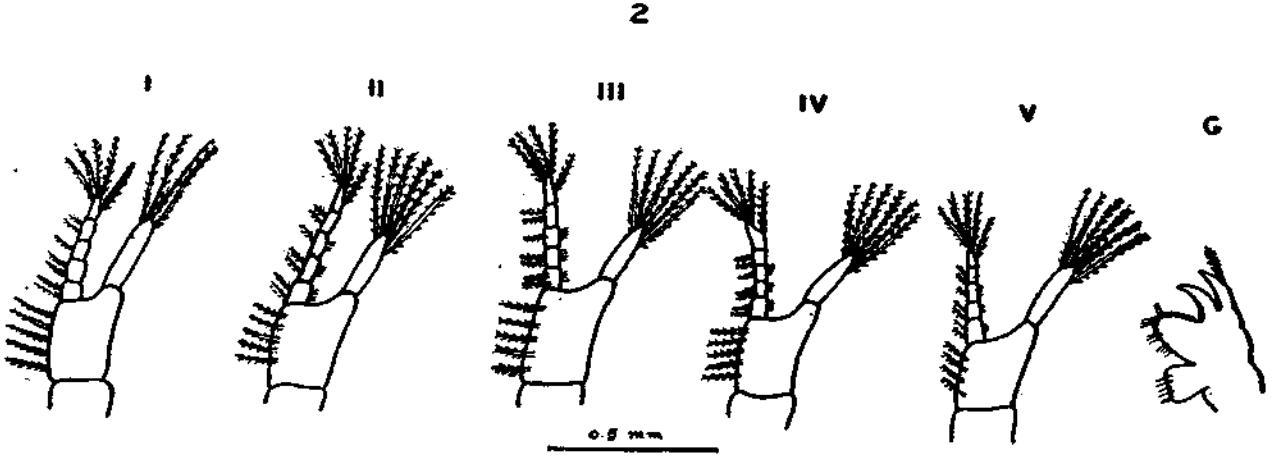


FIG. 1. *Diogenes*, 2nd maxilla of zoaeal stages I to V and glaucothoe (G). FIG. 2. *Diogenes*, 1st maxilliped of zoaeal stages I to V and glaucothoe (G).

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